REPORT 5 FROM A REAPPRAISAL OF THE FOREST SITUATION

PROTECTION AGAINST FOREST INSECTS AND DISEASES IN THE UNITED STATES

U. S. Department of Agriculture - Forest Service

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The following Reappraisal Reports have already been issued by the United States Forest Service:

No. 1. Gaging the Timber Resource of the United States

No. 2. Potential Requirements for Timber Products in the United States

No. 3. The Management Status of Forest Lands in the United States

No. 4. Wood Waste in the United States

No. 5. Protection Against Forest Insects and Diseases in the United States

Foreword

During 1945 and 1946 the Forest Service undertook a reappraisal of the Nation's forest situation. This undertaking, carried out under the general direction of R. E. Marsh, brings up to date previous analyses of a similar nature.

This report covers one aspect of the forest situation. Others deal with different aspects, and with the situation as a whole.

This study of the situation with respect to forest insects and diseases reveals that, although they cause greater losses in standing timber than does fire, much less progress has been made in controlling them. Protection against these pests presents a much more difficult problem.

There is inadequate knowledge of the relation of the hundreds of different kinds of insects and diseases to differing conditions in the forest, especially of how damage caused by them is affected by the change from the uncared-for, wild forest to intensive forest management. In most parts of the country, the activities of man have destroyed the natural balance among native organisms present in the virgin wilderness and have given rise to new and ever-changing conditions of great complexity. And complicating the situation still further is the accidental introduction of a number of foreign pests, some of them highly destructive to our forests.

The authors point out further steps that are needed to reduce losses from forest insects and diseases to a level that is tolerable in commercial timber growing.

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PROTECTION AGAINST FOREST INSECTS AND DISEASES IN THE UNITED STATES

INTRODUCTION

Forests have always been subject to losses from insects and disease. Changes from virgin to second growth and from wild to managed forests lead to decrease in some kinds of damage, but increase the liability to others. The degree to which losses can be reduced in the future will depend on the advances made in the knowledge of insects and diseases and on the opportunity of forest managers to apply it. Only in those rare cases where a new pest is discovered while it is confined to a very limited area will eradication be a possibility. In general, pest control will consist of measures that will keep losses down to the lowest practicable level. This will require the cooperation of foresters and of research workers and control technicians in forest entomology and forest pathology.

Forest insects and diseases rank with fire as causes of drain upon the forest resource. They are less conspicuous, but their total effect probably exceeds that of fire, since they work year after year, and no forest area is free of them. A growing realization of the importance of fire losses has resulted in increases in fire control activities, and losses from fire have been materially reduced. If the magnitude of the damage by forest insects and diseases were similarly recognized and comparable effort were made in their control, the losses they now cause would be substantially reduced.

ENDEMIC AND EPIDEMIC CONDITIONS

Many of the forest insect and disease pests may occur in either endemic or epidemic states, depending upon the absence or presence of favorable environmental factors at any given time. The term "endemic" is here used to mean a low level of pest incidence usually present under normal conditions, in contrast to epidemic.[1/]

In the endemic condition, permanently established forest insects and diseases take a continuous toll which, however, does not greatly reduce the yield of well-managed, thrifty forests, and forest management plans can be adjusted to it. Endemic action is not spectacular, but is erosive in character. In young, fully stocked stands the losses that occur under endemic conditions of infestation or infection may be harmless or even beneficial, especially where only the weaker trees are affected

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1/ The definition, in relation to pest control, adopted by the Committee on Forestry Terminology of the Society of American Foresters.

and the result is a natural thinning of the stand. However, endemic losses may accumulate over a period of years to a point where they may make the difference between a profitable and a losing forestry operation. In mature and overmature stands, for example, losses from wood-rotting fungi may at least equal the growth, extending till much of the wood volume is destroyed. If harvest of such stands is delayed they may deteriorate to the point where they are no longer profitable to log. Many insects likewise cause slow, accumulating losses extending over the life of the stand.

Endemic losses are difficult to control in unmanaged forests and are too often accepted as inevitable. Under good management, with provision for thinnings and improvement cuttings in immature stands, proper selection of crop trees, and timely utilization of dead, decadent, or high-risk trees, such losses can be greatly reduced.

Under present forest conditions in this country, the total annual endemic loss in timber volume offsets far too much of the gross annual timber growth, but no data are available on which to base an accurate estimate of the amount. Timber yields may be materially reduced when the growth of a stand is lowered by defoliating insects or leaf diseases, or young trees are killed and understocking results. The cull caused by heart rot is a heavy loss, especially in overmature stands, and accounts for much of the difference between gross and net annual growth for the country as a whole.

The epidemic state includes the outbreaks of native pests that wreak rapid and marked destruction, and of introduced pests that may cause disastrous losses, possibly even threatening to destroy the host species, as the chestnut, or permanently reducing it to an inferior status. Epidemics usually cannot be predicted far in advance, and it is extremely difficult, if not impossible, to make due allowance for epidemic losses in long-time forest management plans. Because of their unpredictability and severity, epidemic losses appear in the Reappraisal forest-inventory figures as an element of forest drain, in contrast to endemic losses, which are taken into account in calculating net growth.

Endemic and epidemic conditions are not always clearly distinct. Insect and disease pests causing endemic losses may temporarily increase in numbers and severity of attack to the point of causing epidemic losses. Tree-killing bark beetles and other insects may remain in an endemic state for years, causing only slight damage, but always presenting the danger of increasing to the epidemic state with heavy losses when conditions are favorable. The difference may be entirely one of severity rather than of a change in the nature of the pest or its mode of attack. This should be borne in mind in considering losses under the two conditions.

LOSSES FROM INSECTS AND DISEASES

The average annual drain on the forest from insects and diseases in the decade 1934-43 is estimated at 622 million cubic feet. This is a rough estimate representing the more obvious losses, which ordinarily occur under epidemic conditions and are not reflected in the net growth figures. It may be compared with the average annual drain of 460 million cubic feet from fire during the same period.

Losses occurring in the low-level, or endemic state of insect or disease attack are considered separately from those resulting from the high-level, or epidemic state.

Endemic Losses

During periods of normal, or endemic activity in any given forest area, careful examination will reveal that a limited amount of damage is occurring each year. This may be in the form of reduced growth, deformities, lowered quality, or actual killing of trees or parts of trees. For example, the repeated attacks of the white pine weevil, an ever-present destroyer of the leading shoot of white pine in the Northeast and Lake States, result in crooked and forked trees of lowered commercial value. Wood borers, such as the locust borer and ambrosia beetles, infest living trees and lower the value of the wood by boring holes in it. Various bark beetles and borers kill branches and tops of trees, causing reduced growth and deformed crowns.

A myriad of diseases and pathological conditions are endemic in the forest. One of the few leaf and twig diseases whose effects are readily measured is the brown spot disease of young longleaf pines. Over large areas the disease causes seedlings to remain in the "grass stage," without appreciable height growth, for 10 to 15 years, as compared with an average of about 4 years for normal seedlings. Much poor or abnormal growth and some unexplained mortality are undoubtedly caused by root rots or virus infections. Trees weakened by root rots are more readily attacked by bark beetles and are more subject to windthrow. Dwarf mistletoes reduce the growth of western conifers, lower timber quality by causing profuse branching which increases the number and size of knots, and may kill trees of any age. They are especially damaging to seedlings and saplings. Bark canker fungi, wilts, and the several native pine blister rusts kill branches and, oftentimes, trunks.

The effect of tree-killing insects or diseases in dense, young stands cannot be evaluated merely by determining the percent of trees killed. Their harmfulness depends on the degree to which they: (1) Reduce the proportion of the area that is fully stocked; (2) reduce the representation of the more valuable species in a mixed stand; or (3) kill the vigorous trees instead of the weak ones. The southern pine stem rust, for example, is harmful in all three ways.

Examples of endemic losses are given in the Appendix, in table 4, with an indication of the kind of damage, such as reduction in tree growth, lowering of wood quality, or loss of young trees. Regions referred to in this report are shown in figure 1.

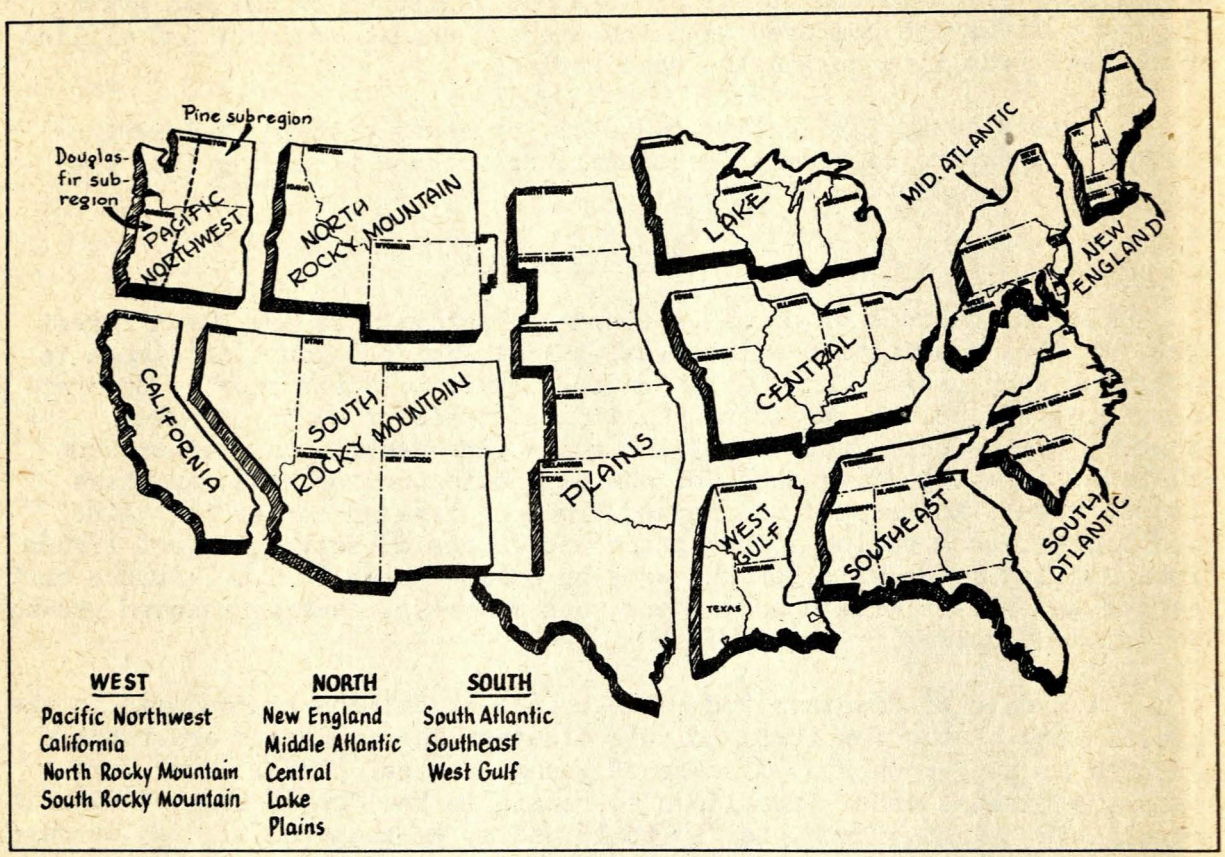

FIGURE 1.- REGIONS USED IN THIS REPORT.

Of the great number of disease organisms which contribute to endemic losses, heart rots are the most important. They are caused by numerous species of fungi. Every tree species in the country is attacked by one or more species of heart rot fungi. Persisting in the tree and working steadily, their effect is cumulative. The gross volume of practically every older timber stand must be decreased by a cull factor to allow for heart rot.

Estimates of heart rot losses are summarized in table 1. The real dollar loss lies somewhere between the values given for stumpage and those for logs. Stumpage prices are appropriately applied to cull trees left standing, while cull logs left in the woods represent values intermediate between stumpage prices and prices of logs at the mill. Material culled in sawing has a higher value than that indicated by log prices. The figures do not reflect the heavy monetary losses in pine and Douglas-fir caused by degrade for firm redheart due to decay not sufficiently advanced to require culling.

Epidemic Losses

Outbreaks of forest insects and diseases, sometimes causing losses so heavy as to jeopardize the financial basis of timber operations, have generally drawn public attention and the concentration of control activities. The information available on the more important outbreaks in the various regions is summarized in table 5 in the Appendix. Most of the estimates of loss are based on very incomplete information.

The destructiveness of certain insect epidemics is well known. History records the occurrence of four outbreaks of budworm on spruce and balsam fir in eastern Canada and northeastern United States, the fourth of which is now in progress. Losses in each of the first three were evidently severe. The current epidemic has thus far caused greatest loss in Canada, but the situation in New England is becoming serious. Very heavy losses are anticipated in New England unless control can be established. The larch sawfly epidemic in the Lake States caused the loss of practically all the mature larch stands in the region.

The epidemics of bark beetles on ponderosa pine, western white pine, and lodgepole pine in the Rocky Mountain and Pacific coast regions have been numerous and severe, and have caused heavy losses with very little salvage. The recorded losses are doubtless far short of the total.

The destructive power of introduced diseases is illustrated by the spectacular epidemic of chestnut blight in the Eastern States, which in 40 years completely destroyed the chestnut over its commercial range, and by that of the white pine blister rust, which spreads rapidly and now has invaded all regions where white pine occurs. In the loss of white pine reproduction its effect has been severe.

Deterioration of Timber Products

Wood waste is a large element in the commodity drain. Deterioration of logs, lumber, pulpwood, and other products caused by insects and fungi, often avoidable, accounts for an important part of this waste. More wood has to be cut to replace that damaged or degraded by these organisms and by marine borers. Blue stain and ambrosia beetles in logs and lumber, powder post beetles in stored wood, and decay and termites

Table 1.--Estimated heart-rot losses in saw-timber stands, United States, 1945 [1/]

Species	Saw-timber stand [2/]			Average cutting age of saw timber	Mean annual cull volume	1943 prices [3/]		Value of mean annual cull at 1943 prices	
	Gross volume	Cull				Stumpage	Logs at the mill	Stumpage	Logs
	Million bd. ft.	Per-cent	Million bd. ft.	Years	Million bd. ft.	Dollars per M bd. ft.	Dollars per M bd. ft.	Dollars	Dollars
Eastern hardwoods:									
Oak	125,162	19	23,781	150	158.5	9.49	30.68	1,504,000	4,863,000
Beech, birch, maple	85,933	21	18,046	125	144.4	10.20	63.58	1,473,000	9,181,000
Redgum	30,432	13	3,956	80	49.5	9.05	37.30	448,000	1,846,000
Yellow-poplar	14,357	14	2,010	80	25.1	11.08	50.55	278,000	1,269,000
Cottonwood and aspen	17,798	12	2,136	40	53.4	5.77	24.02	308,000	1,283,000
Others	91,509	18	16,472	100	164.7	11.31	42.93	1,863,000	7,071,000
					595.6			5,874,000	25,513,000
Eastern softwoods:									
Southern yellow pine	194,152	3	5,825	60	97.1	9.70	20.09	942,000	1,951,000
Hemlock	16,956	12	2,035	110	18.5	4.51	25.71	83,000	476,000
Spruce and fir	29,678	9	2,671	150	17.8	5.85	31.64	104,000	563,000
White and red pine	16,193	5	810	75	10.8	7.81	27.30	84,000	295,000
Cypress	7,513	17	1,277	300	4.3	10.74	23.97	46,000	103,000
Others	8,710	11	958	150	6.4	6.47	30.87	41,000	198,000
					154.9			1,300,000	3,586,000
Western softwoods:									
Douglas-fir	505,915	15	75,887	230	329.9	3.47	24.36	1,145,000	8,036,000
Ponderosa pine	193,168	4	7,727	230	33.6	4.31	18.42	145,000	619,000
Western hemlock	121,509	20	24,302	200	121.5	1.74	21.76	211,000	2,644,000
True firs	138,465	18	24,924	200	124.6	1.73	25.35	216,000	3,159,000
Redwood	42,349	10	4,235	400	10.6	2.10	16.21	22,000	172,000
W. white & sugar pine	42,791	6	2,567	200	12.8	6.09	22.88	78,000	293,000
Lodgepole pine	23,978	8	1,918	125	15.3	2.21	19.12	34,000	292,000
Spruce	40,773	12	4,893	250	19.6	4.27	25.89	84,000	507,000
Others	93,340	20	18,668	200	93.3	2.76	23.36	257,000	2,179,000
					761.2			2,192,000	17,901,000
Grand total					1,511.7			9,366,000	47,000,000

1/ Adjusted from 1940 tabulation of Geo. H. Hepting, Bureau of Plant Industry, Soils, and Agricultural Engineering.
2/ Figures used are from Basic Forest Statistics, Reappraisal Project, U. S. Forest Service, Washington. 1946.
3/ Stumpage and Log Prices for 1943 by H. B. Steer, on file U. S. Forest Service, Washington.

in wood in storage and in use reduce or destroy the usefulness of large volumes of wood. Decay loss of stored pulpwood in the North is estimated at 6 percent. In poles, posts, ties, piling, mine timbers, and especially in structures exposed to water, such as porches, steps, platforms, and bridges, decay necessitates more replacements than fire. Damage by termites and decay in buildings, although perhaps less than commonly represented, nevertheless requires an appreciable amount of lumber for repairs and partial replacements, and sometimes hastens the date of complete replacement. In terms of dollars, decay losses in timber products are much larger than in standing timber, because of the higher value of finished material and the large labor cost of replacements. The losses in products continue to be important, despite countermeasures that far exceed those yet begun to protect standing timber. However, this report does not include an estimate of losses in timber products or a discussion of their control.

STATUS OF PROTECTION

Protection against forest insect and disease pests has taken four forms: (1) Research to establish facts upon which control could be based; (2) limitation on imports to exclude foreign pests or hinder their spread, and inspection of domestic nursery stock for infections; (3) control programs to reduce epidemics; and (4) application of silvicultural and forest management practices to create stand conditions unfavorable for insects and diseases.

Research

Research has largely been conducted by public agencies. Within the Federal Government, the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Bureau of Entomology and Plant Quarantine, Department of Agriculture, have carried on research in the control of forest diseases and forest insects, respectively. Through its research in silviculture and forest management, the Forest Service is working cooperatively with these bureaus to integrate protection against insects and diseases with forestry practices. Knowledge of the life histories and habits of the various forest pests is basic to the development of forestry practices that will aid in reducing future losses. Such information is now being applied, for example, in programs dealing with the white pine blister rust, gypsy moth, white pine weevil, and certain western bark beetles. The Bureau of Plant Industry, Soils, and Agricultural Engineering, and the Bureau of Entomology and Plant Quarantine have also given much valuable service in the technical direction of direct control programs, materially aiding the public land-managing agencies and private landowners.

Good progress has been made in improving control techniques in large-scale operations. For example, in the case of the white pine blister rust a combination of direct and indirect measures involving the eradication of ribes (the plants including gooseberries, currants,

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etc., that serve as the alternate host of the disease) through physical, chemical, and silvicultural means, has served to control the disease on more than 10 million acres. No further control measures will be necessary on this area until some major ecological change, such as that caused by logging or fire, results in an increase of ribes.

Another well-known pest, the gypsy moth, is now being effectively combated by spraying from aircraft with DDT. This method gives much promise of successful application in the control of a wide variety of destructive insects.

Research workers in several fields have combined their knowledge to make possible the development of these and many other improved measures, and have also rendered increasingly better service in the technical direction of control operations in the field.

Some States have conducted research in the control of forest insects and diseases, largely through their experiment stations and forestry schools. State efforts, with a few exceptions, have been much more limited than those of the Federal Government, but are now being increased.

Private research efforts in these fields also have been relatively small. Members of the faculties of a few privately endowed colleges and universities have carried on research in forest entomology and pathology, and commercial developments in wood preservatives, herbicides, and insecticides and in equipment for their application have been of direct value in prevention of wood losses and in field control operations.

In general, research has been on too small a scale to keep abreast of the heavy demands for effective measures to control the various destructive insect and disease pests—native and introduced—to which the forests have been subject. Control measures may thus be undertaken without the support of sufficient prior and contemporaneous research, with the result that they may be ineffectual or uneconomical.

Prevention of Pest Introduction

Quarantine and inspection to exclude dangerous material from abroad are the responsibility of the Bureau of Entomology and Plant Quarantine.

All forest trees and forest nursery plants are now excluded from the United States except under permit and inspection on arrival. If a dangerous disease or insect is known to exist on a foreign tree species, that species may be prohibited entry. However, provision may be made for entry of limited quantities which can be adequately safeguarded for experimental purposes by the United States Department of Agriculture.

There is no restriction on the importation of seed unless it is known to carry a specific disease. No general safeguards are considered practicable on the entrance of wood, either in the form of logs or in less dangerous forms such as packing cases or paper pulp. Both seeds and wood sometimes bring in destructive foreign diseases or decay organisms. Logs and crates of elm proved to be the vehicles of entry for the Dutch elm disease and the bark beetle that carries it. Domestic quarantine is sometimes used to delay the spread of introduced insects and diseases within the country.

Control Programs To Reduce Epidemics

Public agencies and private owners of forest lands have the joint responsibility for controlling forest insect and disease epidemics. For many years public agencies have given leadership by pointing out the need for control and by giving technical help in control work on private lands. Limitation of legal authority and financing, however, has generally prevented adequate action except in specific cases where authority and funds have been provided for combating destructive introduced pests. The public land-managing agencies have tried to protect their own lands and oftentimes have assisted in the protection of adjacent or intermingled private lands.

Recent years have seen an increasing realization of the need for better financing and organization of public leadership in forest protection and for greater public assistance to private landowners. The establishment of the Clarke-McNary principle of public leadership and aid in fire control led the way to new formulas in programs of protection against forest insects and diseases. Justifications for Federal partieipation in pest control are generally similar to those for fire control:

1. A large national interest is involved, because, irrespective of ownership, resources of wide public concern are jeopardized.

2. Symptoms of inception of epidemic outbreaks are generally evident only to a technically trained staff.

3. Control of an epidemic can be secured only by the consistent application of control measures over the entire area involved, without respect to ownership or State lines. Failure of one landowner to apply control, either through unwillingness or financial inability, may jeopardize or even nullify the control program over a large area of other lands, including Federal lands.

4. Epidemics generally occur through no fault of the individual landowner and constitute an unforeseeable and uninsurable risk against his enterprise.

Participation by the States in control programs is based on similar justifications. In practice, their participation has been limited and, with a few exceptions, has not equaled that of the Federal Government in the protection of privately owned forests. State appropriations alone have often been inadequate for protection of State-owned forests without the supplementary aid given by the Federal Government. Appropriations by the States for control work have generally been correlated with Federal and private expenditures. Frequently they have qualified the State for Federal cooperation under one or more of the several Federal laws described on pages 15-17 of this report.

A few States are now taking a strongly active part in insect control projects and have legislation which enables them to take prompt action in establishing zones of infestation, drawing up cooperative agreements with private owners, and applying control measures.

Private forest landowners have participated in control by protecting their own lands, sometimes individually and at their own expense, but more often as part of a cooperative control program with leadership and part of the cost provided by public agencies. Not infrequently, they have cooperated as groups with public agencies. In the Western States some private forest protective associations have assessed their members for control work in cooperation with public agencies. This group participation by private interests has the advantage of simplicity and of uniform action and financing and is to be encouraged.

Well-Managed Forests the Best Defense Against Insects and Diseases

The tendency thus far has been to depend upon artificial, or direct, control measures rather than upon the modification of forest conditions, through silvicultural and forest management practices, to make them less favorable for insect and disease outbreaks—so-called indirect control. This is not surprising in a country where the forests are still largely unmanaged and where several accidentally introduced foreign pests have added to the number and severity of epidemics.

In the long run, healthy, growing forests, well-suited to the site and able to resist attack, will be the best defense against most insects and diseases, and more attention should be given to testing and applying the indirect methods of control.

Measures taken at the time of stand establishment, or cuttings to control density of stocking, species composition and arrangement, or age distribution are the principal tools of the forester in creating

or modifying stand conditions to reduce insect and disease losses. For example, loss in quality from white pine weevil attack may be reduced by growing eastern white pine in dense stands for the first 20 years or so, or in mixture with hardwoods, particularly where the pines are partially suppressed by the hardwoods. Locust borer damage may be reduced by growing black locust on sites well adapted to the species and by keeping the stands fully stocked so that the boles of the trees are shaded. Stands of spruce and fir with a high percent of mature balsam fir are particularly susceptible to the spruce budworm. Reducing the percent of balsam, together with partial cuttings at relatively short intervals, has been recommended by research workers as a means of preventing outbreaks of the budworm. Although this recommendation was first made some 20 years ago, following widespread outbreaks during the period 1910-1926, no attempt was made to apply such practices until the beginning of the current outbreak. Large study areas are now being established in New England to test the effects of various forestry practices.

The practice of selectively cutting "high risk" ponderosa pine trees, recognizable by certain external symptoms as being susceptible to western pine beetle attack, has been effective on certain test areas in reducing the population of beetles. At the same time, valuable timber has been salvaged which otherwise would have been lost. Public agencies as well as a number of private timberland owners in California, Oregon, and Washington have adopted this practice. Its extension to much more of the ponderosa pine acreage in the Pacific Coast States is desirable.

Further research will probably bring better knowledge of the factors that affect individual tree susceptibility and make recognition of symptoms of decadence more certain. Similar studies are needed for other regions and for other tree species subject to bark beetle attack.

There is evidence that losses caused by the mountain pine bark beetle in mature stands of western white pine mixed with other conifers in the North Rocky Mountain region can be reduced by cuttings that remove a considerable part of the volume of associated species from the stand. These stands have reached a stage in their ecological development where climax species, such as the true firs and hemlock, are gradually replacing the more valuable white pine. The pine is a temporary species that cannot, in the long run, compete successfully with the climax species unless the progress of natural succession is checked. Partial cuttings favoring white pine would improve the vigor of this highly important species and increase its resistance to attack by the bark beetle. Extensive tests are now being made to obtain more definite information on this method of indirect control.

In New England, recent studies have shown that ground-cover conditions have an important effect on the gypsy moth population. In stands on moist sites where there is an abundance of shrubby and herbaceous growth, the gypsy moth caterpillars spend more time on the ground than

they do in open stands on dry sites and where ground cover is sparse. On the ground their natural enemies are much more effective. This discovery is of value in supplementing previous knowledge of the preference of the caterpillars for the foliage of certain tree species. The hazard of gypsy moth attack can be reduced by favoring a good density of tree stocking with a well-shaded forest floor and a stand containing a substantial proportion of species not in the preferred food class.

Prompt utilization of fire-killed or wind-thrown timber prevents its rapid deterioration and the build-up of large populations of bark beetles or wood borers that may attack nearby living timber. For example, the present extremely destructive outbreak of the Engelmann spruce beetle in Colorado is the result of an enormous initial build-up of the beetle population following a windstorm that blew down extensive stands of spruce in 1939. The Douglas-fir beetle killed some 200 million board feet of mature Douglas-fir in stands adjacent to the Tillamook burn of 1933 in Oregon.

In the control of diseases, such measures as pruning branches, controlled burning, and felling snags have proved effective. Proper selection of crop trees and, in some species, crop tree pruning in stand improvement treatments in the Black Hills, South Dakota, and in State and Federal forests in the East have decreased liability to heart rots and bark cankers. Prescribed burning as practiced in places in the southern pine belt has reduced infection from a needle disease that is a serious handicap in young stands. Controlled surface fires give promise of effectively supplementing the ribes eradication campaign to stop the white pine blister rust in Idaho.

The felling of snags, primarily to reduce fire hazard, also has had value in reducing the amount of infectious heart-rot material in some species, though in ponderosa pine stands snag cutting may actually increase the infection hazard. In oak within the national forests in the Appalachians, Douglas-fir in the Northwest, and white fir in California, external symptoms of heart rot have been taken into account in marking trees for cutting. Information now available on the increase in decay with increased tree age permits the adjustment of the cutting cycle to prevent serious losses from decay in balsam fir, aspen, Appalachian oak, and four important western species—Douglas-fir, incense-cedar, western hemlock, and ponderosa pine, though for only part of the range of each.

The extensive second-growth oak forests in the East are largely of stump sprout origin and, without treatment, will produce only low-grade timber. The dominant sprouts in a clump are likely to become infected with heart rot when the parent stump decays, because of their origin high on the stump. In contrast, sprouts starting near the ground line are much less likely to be infected. Forest pathologists have found that at any time before the stand is 15 years old, sprouts with a low risk

of decay can be readily distinguished from those with a high risk. By cutting infected dominant sprouts to free sound, subordinate sprouts, the potential value of the stand for timber production is greatly increased.

COST OF CONTROL

During the period 1936-1945 the principal control programs were directed against the white pine blister rust, gypsy moth, and western pine bark beetles. There was an average annual expenditure of nearly 4.4 million dollars by the Federal Government and 1.4 million dollars by the States and private agencies (table 2). A considerable part of the Federal money was spent on Federal lands, but more Federal than nonfederal money was spent on State and private land, especially for control of introduced pests. For example, in the case of white pine blister rust control, which accounted for over half the total expenditures in the decade, official reports for the Northwest show that in the 1945 and 1946 fiscal years $274,870 of Federal money was spent on State and private lands as against $61,675 of State and private money.

In view of the widespread occurrence of such destructive pests as bark beetles, the spruce budworm, the larch sawfly, and the hemlock looper, and the heavy losses they have caused, the insignificant expenditures for their control indicate a lack of recognition of their importance. This is explained, at least in part, by the fact that they are native insects, always present in an endemic state and increasing to epidemic proportions only occasionally. Thus they lack the dramatic interest of a newly introduced foreign pest. A much greater expenditure for their control could be justified in the reduction of the large losses such as have been experienced in the past.

During the decade Federal funds were supplied in part through regular appropriations for the department concerned and in part through emergency appropriations supporting such programs as the Civilian Conservation Corps, Emergency Conservation Work, and Works Progress Administration (table 3).

This period 1936-1945 saw the end of the large allocations of funds as part of the depression emergency programs. For the first half of the decade (1936-40) the average total annual appropriation was 5.9 million dollars, of which 1.6 was from regular and 4.3 from emergency appropriations. As the emergency allotments came to a halt, the average total annual expenditure in the second half of the decade dropped to 3.1 million dollars. Regular appropriations, however, increased to an average of 2.6 million, although the war was making unprecedented demands for funds. This increase signifies growing public recognition of the economic importance of forest insect and disease control.

Table 2.--Expenditures for forest insect and disease[1/] control and research, 1936-45

(Thousands of dollars)

BY AGENCIES

Fiscal year[2/]	Forest Service[3/]	PISAE[4/]	EPQ[5/]		Dept. of Interior[3/]	Total Federal	State & private	Grand total
			Research	Control				
1936	729	185	165	6,342	122	7,543	1,330	8,873
1937	751	191	175	7,556	40	8,713	1,410	10,123
1938	790	193	250	3,846	77	5,156	1,315	6,471
1939	817	145	251	3,368	70	4,651	1,374	6,025
1940	1,039	152	250	2,728	22	4,191	1,477	5,668
1941	800	143	211	1,814	23	2,991	1,323	4,314
1942	789	133	206	853	115	2,096	1,397	3,493
1943	1,140	123	198	1,151	175	2,787	1,406	4,193
1944	1,208	98	168	1,208	176	2,858	1,384	4,242
1945	1,330	101	220	1,238	206	3,095	1,365	4,460
Total	9,393	1,464	2,094	30,104	1,026	44,081	13,781	57,862

BY PROGRAMS

	Federal	State and private	Total
Gypsy moth control[6/]	12,919	10,950	23,869
Other forest insect control (chiefly western bark beetles)	1,359	132	1,491
White pine blister rust control	26,245	2,499	28,744
Research	3,558	7/ 200	3,758
All programs	44,081	13,781	57,862

1/ Dutch elm disease not included because expenditures have been largely for control on shade trees.
2/ Ended June 30 of year given.
3/ For control.
4/ For research by Bureau of Plant Industry, Soils, and Agricultural Engineering.
5/ Bureau of Entomology and Plant Quarantine.
6/ Includes brown-tail moth control.
7/ Estimate.

Table 3.—Federal appropriations for control of forest insects and diseases
(Thousands of dollars)

Year	Regular appropriations	Emergency appropriations	Total appropriations
1936	1,318	6,633	7,951
1937	1,443	6,079	7,522
1938	1,627	3,456	5,083
1939	1,689	3,057	4,746
1940	1,897	2,274	4,171
1941	1,893	1,824	3,717
1942	2,113	875	2,988
1943	2,802	—	2,802
1944	2,813	—	2,813
1945	3,089	—	3,089
Total	20,684	24,198	44,882

FEDERAL LAWS RELATING TO INSECT AND DISEASE CONTROL

Control operations have demonstrated the need for common action by Federal, State, and private interests, particularly where lands in different classes of ownership are intermingled. They have also shown the need for a legal basis upon which common action can rest. The progressive development and strengthening of Federal and State legislation has provided for greater public participation in control programs. The general trend in Federal legislation has been toward broadening authorization for certain Federal agencies to participate in control work cooperatively with State and private agencies. A brief summary of the Federal laws now in effect will illustrate this trend.

The various acts providing for the establishment and management of the National Forests provide for their protection from fire, injurious insects, and diseases.

The Deficiency Act of December 15, 1921 (42 Stat. 327, 331), provided an appropriation to enable the Secretary of Agriculture to prevent further loss of timber from insect infestations within the National Forests and on other lands owned or administered by the United States in Oregon and California (the Oregon and California and Coos Bay Wagon Road Revested Grant Lands), and also for cooperation with the Department of the Interior. It stipulated that

> no part of the appropriation, except necessary expenditures for preliminary investigations, shall be expended unless the States of Oregon and California, or the owners of pine timberland

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adjacent to or intermingled with lands owned or administered by the United States, shall have satisfied the Secretary of Agriculture that the insect infestations on said adjacent and intermingled lands will be abated, in accordance with State law or voluntarily by the owners of such lands to the extent necessary in the judgment of the Secretary of Agriculture to protect the timber on lands owned or administered by the United States from reinfestation.

This was the first act to provide specifically for control of a native forest pest, but it was not basic legislation. For the situation concerned, the last stipulation quoted prevented control work on Federal lands unless parallel action was taken on adjacent or intermingled State and private lands.

The Clarke-McNary Act of June 7, 1924 (43 Stat. 653), provides for protection of forest lands from fire and stipulates conditions under which Federal funds can be expended for fire protection on lands not in Federal ownership. This established the principle of cooperative protection.

The McSweeney-McNary Act of May 22, 1928 (45 Stat. 699), provides for forest research, including research in protection. It specifically authorized appropriations for research in forest insects and diseases.

The Joint Resolution of April 6, 1937 (50 Stat. 57), authorized the Secretary of Agriculture to control incipient and emergency outbreaks of insects and diseases. It authorized the appropriation of $2,000,000 to the Bureau of Entomology and Plant Quarantine to carry out the purposes defined, this fund to be available until spent, and authorized subsequent appropriations to maintain the fund at $2,000,000. It did not specifically stipulate State or private cooperation and had as its primary purpose to provide authorization for control of insects and diseases on agricultural plants, and especially those listed in the joint resolution. It was reenacted in an amended form the following year.

The reenactment, approved May 9, 1938 (52 Stat. 344), is now commonly referred to as the Incipient and Emergency Pest Control Act. It authorized and directed the Secretary of Agriculture to apply methods of control to enumerated crop pests, and to all types of insect and disease pests when they occur as emergency outbreaks or incipient infestations or infections. The control activities are to be in cooperation with authorities of the States concerned, organizations, or individuals. It also provided that, in the discretion of the Secretary, no part of the sums appropriated under its authorization may be expended for control of incipient or emergency outbreaks until the State concerned has provided the organization or materials and supplies deemed necessary for cooperation with the Federal Government. Though limited to incipient and emergency outbreaks, it was the first act of Congress that specifically authorized expenditure

of Federal funds for control of insect pests and plant diseases on lands not in public ownership.

The legislation of April 26, 1940, commonly referred to as the Lea Act (54 Stat. 168, 169), applies only to the control of white pine blister rust. It authorizes the Secretary of Agriculture to use funds made available for the control of white pine blister rust to prevent the spread to and eliminate the rust from all forest lands, irrespective of ownership. It provides, however, that in the discretion of the Secretary, no such funds may be expended on State or private lands until sums equal in amount to the proposed Federal expenditures on those lands have been made available, except where such State or private lands are so intermingled with those in Federal ownership that protection work on them is necessary to protect the Federal lands. It further provides that any plan for control of the disease on Indian lands shall be approved by the Federal agency or Indian tribe having jurisdiction over such lands, and that the Secretary may allocate funds appropriated under this Act to such Federal agencies for expenditure for the purposes of the Act.

The Department of Agriculture Organic Act of 1944 (58 Stat. 734-743), authorizes the Secretary of Agriculture, either independently or in cooperation with States, political divisions thereof, farmers' associations and similar organizations, and individuals, to carry out measures to control a stipulated list of insects and diseases occurring mostly on agricultural crops, but including the gypsy and brown-tail moth and Dutch elm disease. The authorization stipulates that "the cooperating foreign country, State, or local agency shall be responsible for the authority necessary to carry out the operations or measures on all lands and properties within the foreign country or State other than those owned or controlled by the Federal Government * * *." All the authorizations in this act are specific, not general, and only three forest pests are mentioned. Reference in the act to cooperation with a foreign country applies to Mexico and only to the pink bollworm and the Mexican fruit fly. The act is of interest to this discussion, however, because it clearly indicates the policy of cooperation with other governmental bodies and with private persons and organizations.

The Agricultural Appropriation Act for fiscal year 1944 (57 Stat. 392-406) prohibited the use of Federal funds for the removal of trees affected with Dutch elm disease except on federally owned property. States were required to bear the cost of removal of diseased trees. This limitation, which has been continued in the subsequent appropriation acts, made it necessary to materially change the cooperative control program then in progress against the disease in both cities and forest areas. It did not specifically prohibit the use of funds to remove beetle-infested trees not yet attacked by Dutch elm disease (to prevent multiplication of beetles transmitting the disease), but probably it was intended to do so, and therefore the Bureau of Entomology and Plant Quarantine also eliminated that phase of the work.

FUTURE OUTLOOK AND NEEDS IN PEST CONTROL

There is no cause for optimism concerning the occurrence of insect or disease epidemics. They must be expected in the future. One introduced fungus disease has wiped out the American chestnut. Secondary white pine species such as limber and whitebark pine may be destroyed by the white pine blister rust, and the white pine species of high commercial value may be confined to the more productive areas, where control will be economically justified. Destructive epidemics of such insects as the bark beetles and spruce budworm may be expected when environmental conditions favor their breaking out from the endemic state. These hazards must be faced squarely. Control work of the past should be reviewed; any limitations inherent in its organization should be recognized and removed; and a strong program designed to lessen the shock and limit the losses of future epidemics should be developed.

Although much extremely worth-while research has been performed and has served as the technical basis for control, the amount of research has not been commensurate with the values threatened or the losses sustained. A considerable expansion of the research program is needed. Only research can yield the additional information necessary for more effective and economical control methods.

It has been insufficiently recognized that a well-organized detection system could prevent the development of many incipient outbreaks into epidemics. Epidemics do not often flare up suddenly over large areas without previous indication of their approach. Native insects and diseases occurring in an endemic state may cause epidemics by spreading from a few centers where conditions are especially favorable to their development. Introduced pests likewise generally develop first in local areas of infection or infestation, and later gradually extend their range over large areas. The discovery of these conditions in time to institute corrective action should not be left to chance but should be provided for in a permanent detection system and organization.

Not enough is known about foreign pests. Numerous additional species may be introduced and prove to be destructive here. If the requisite advance information about them is lacking, some may be admitted that might have been kept out. The legal authority and inspection machinery for preventing their entry are well developed, but they cannot be applied against all importations indiscriminately. Only commodities known to harbor dangerous pests can be excluded. There is not enough information on which to base a thoroughly efficient selective quarantine. Most nursery stock is excluded. But many other objects, like the burl elm logs that brought in the Dutch elm disease, cannot be excluded without knowledge that they present a definite hazard. This knowledge can come only from special research abroad.

In too many past instances, valuable time has been lost in starting control measures for epidemics while awaiting special appropriations from the Congress or State legislatures, or concerted action by private interests. The situation is analogous to fire control in that prompt action may materially lower both the costs of control and the losses. It is readily apparent that when control of an epidemic is undertaken it must be aggressively carried through to completion. Failure to continue a control operation at the proper level throughout its course may easily nullify the undertaking.

For most epidemics, control programs must be applied uniformly and promptly over all lands involved, regardless of ownership. Failure to do so may jeopardize the entire program. But concerted action by all landowners is hard to get. Some may be financially unable to meet the costs, and others, because of lack of understanding or other reasons, may fail to participate. Furthermore, the stands to be protected are seldom distributed uniformly. Stands belonging to one owner may contain only a scattering of the susceptible species and may have little value. To demand that this owner pay all the costs of control on his lands would be inequitable. But failure to apply control treatment to his land might endanger heavier stands of the threatened species on the lands of nearby owners. Also, some adjacent lands may be in a different State.

The most effective way to get satisfactorily prompt and uniform action usually is through leadership and participation by public agencies, both Federal and State. The summary of Federal law in this report shows that, although progress has been made in developing legal authorization for Federal action, a broader law is needed. Legislation designed to correct this weakness was recommended by the Department of Agriculture to the 79th Congress and bills were introduced in both Houses (S. 1863 and H.R. 7111). Identical bills were introduced in the 80th Congress (S. 597, H.R. 1974, and H.R. 2615). To be cited as the "Forest Pest Control Act" if it becomes law,2/ the proposed legislation states that

> * * * it shall be the policy of the Government of the United States independently and through cooperation with the governments of States, Territories, and possessions, and private timber owners to prevent, retard, control, suppress, or eradicate incipient, potential, or emergency outbreaks of destructive insects and diseases on, or threatening, all forest lands irrespective of ownership.

These bills would authorize the Secretary of Agriculture either directly or in cooperation with other departments of the Federal Government, or with States or private interests (1) to conduct surveys on any forest lands to detect and appraise forest insects or diseases, (2) to determine

2/ This legislation became effective as Public Law 110, June 25, 1947.

the measures to be applied on such lands for control, and (3) to plan, organize, direct, and carry out control measures. Operations on lands managed by other agencies of the Federal Government would be conducted with the consent of the agency having jurisdiction and the Secretary of Agriculture could make allocations of the funds authorized to other Federal agencies having jurisdiction over Federal lands to carry out the stated purposes. However, none of these funds could be expended on State or private lands "until such contributions toward the work as the Secretary may require have been made or agreed upon in the form of funds, services, materials, or otherwise."

This proposed legislation is notable for several reasons:

1. It establishes a Federal policy concerning control of forest insects and diseases. In doing this, it recognizes the need for surveys, determination of control methods, and the application of control.

2. It applies to all forest insects and diseases.

3. It places on the Secretary of Agriculture responsibility for leadership in the protection of all forest lands and provides a basis for cooperation with State and private agencies.

The "Forest Pest Control" bills follow substantially the recommendations of the Department of Agriculture to the Joint Congressional Committee on Forestry in 1940, and other later recommendations.

Eventually, a marked reduction in insect and disease losses can be expected through the more general application of good forestry practices. The conversion of overmature forests to thrifty, growing forests will eliminate the trees most susceptible to attack from many organisms. This is clearly true in the case of certain bark beetles. Also, the development of high-grade timber forests on commercial rotations will prevent much of the heavy loss from heart rots that nearly always cause decay in old stands growing under wild conditions.

There are some exceptions to the rule that youth and vigor bring greater security against insects and diseases. For example, blister rust threatens young white pines much more than the mature trees, and control is generally more difficult and costly in very young stands. Certain sawflies, tip moths, and twig weevils are more prevalent and destructive in very young stands than in older timber.

Furthermore, where stands are established by planting, biological conditions are unnatural in many respects and may actually increase the hazards of pest outbreaks. Heavy losses have been experienced, especially in plantations of species not well suited to the site; better plantation design would have lessened such losses. Also, cultural treatments in old stands, previously untreated, cause changes in the physical

environment which may increase susceptibility to secondary injury by insects or diseases. For example, heavy selective cutting in old stands of such species as birch or eastern hemlock is often followed by rapid deterioration of the residual stand, presumably due to the sudden opening of the canopy and changes in light, moisture, and temperature conditions.

Nevertheless, application of forestry practices to the extent that it produces vigorous, rapid-growing crops of trees of species composition well adapted to the site, will in general reduce losses from insects and diseases.

The well-managed forest of the future will be accessible and closely utilized. A road system adequate for fire protection and for utilization of products will make all parts of the forest accessible for insect and disease control and will permit salvage of timber killed or dying by the action of forest pests. The condition of greater accessibility will facilitate control operations, lower costs, and simplify the job of detection of incipient outbreaks. As markets for wood products expand and provide more favorable outlets for more classes of products, salvage of material will become increasingly practicable. Economic conditions permitting salvage of all kinds of trees, large or small, at a profit or even merely without financial loss, will help prevent centers of infection or infestation from developing, permit better general forest sanitation, and thus reduce losses.

As for wood products, deterioration in the future may be expected to be less than at present. The larger proportion of lumber dipped or kiln-dried should further decrease the amount degraded by sapstain and ambrosia beetles. The loss of pulpwood in storage is being reduced by prompter utilization. Wood is now less used in porches, sidewalks, culverts, and other similar construction in situations favorable for rapid decay. The increasing use of preservatives is helping to relieve excessive drain on species having durable wood, formerly required for such purposes as poles and railroad ties.

A PLAN FOR CONTROLLING FOREST INSECTS AND DISEASES

Adequate Nation-wide control of forest insects and diseases requires action by the Federal and State Governments and by private owners of forest land.

The plan here outlined visualizes Federal responsibility for leadership in the correlation of activities to accomplish Nation-wide protection against these pests. This is because of the national interest in forests and in the flow of forest products to consumers, in social and economic stability through permanence of the forest industries, and in the protection of land, watershed, and other values through maintenance of an adequate forest cover. Such protection requires action as needed to control the ravages of forest pests and prevent undue loss.

The Federal Government is obviously responsible for administration and protection of Federal lands in a manner that will protect their values and prevent the spread of pests to neighboring properties. It is thus the duty of the Federal agencies to conduct the necessary insect and disease control activities on Federal lands.

The Federal Government also has responsibility for general leadership in forest insect and disease research. Here State and private agencies are expected to do all they can, but it devolves upon the Federal Government to see that the Nation as a whole has the necessary technical information on which to base control. This entails a large amount of Federal research, as well as of State and private research. The Federal Government would act as a national clearing house for research findings.

The States have a somewhat similar responsibility for control work on State and private lands within their respective borders. There is a great need for State initiative and action in protecting the forests against insects and diseases. Where the States and the Federal Government are carrying on research or control operations in the same fields, their activities should be correlated by mutual arrangement. Where they are doing research on the same problems or undertaking control in the same territory, their activities should usually be on a cooperative basis. Many forest pests are common to an entire region, and epidemics frequently extend across State boundaries, making cooperation between States, and between States and the Federal Government, necessary for efficient control.

The private landowner's responsibility is to protect his forest so as to prevent it from becoming a danger or nuisance to his neighbors. He therefore should combat insect and disease pests to the best of his ability, either individually or through participation in cooperative control.

Elements of the Plan

The main elements of a national plan to reduce insect and disease losses to a tolerable level are: (1) Research to provide a sound basis for effective control methods; (2) a detection system which, by needed surveys and observations by competent technicians, will locate potentially dangerous centers of outbreak and incipient outbreaks; (3) a control organization equipped and ready for immediate action; (4) application of silvicultural and forest management practices that will increase the resistance of forests to insect and disease attack; and (5) education of private owners and the general public in the principles of forest protection.

Adequate protection will not be attained merely by greater expenditures. Also needed are better organization, carefully planned detection, and quick control action when emergencies arise.

Research

As previously indicated, the necessity for long-continued, Nation-wide research, the results of which are applicable to all classes of forest land, calls for Government leadership and participation. Correlation between Federal and State activities doubtless will always be arranged between the Government and the individual State, and not conform with any rigid Nation-wide pattern.

An adequate Federal program of research would include:

(1) An enlarged program of field studies by adequately staffed units of forest entomologists and pathologists working in close association with the Forest Experiment Stations of the Forest Service, State universities, agricultural experiment stations, and other agencies conducting research in these fields. These units should conduct research on the insects and diseases affecting each important timber type. The organization could be patterned on the present field stations of the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Bureau of Entomology and Plant Quarantine.

Basic research should be carried out at central regional stations where adequate facilities of laboratories, greenhouses, and other equipment are available.

(2) Foreign studies, particularly in Asia, of dangerous foreign pests that might get into the United States. American timber species should be grown at several places in each continent and kept under systematic observation to determine their susceptibility to foreign pests. Those insects and diseases that prove virulent on our species should be given enough study to determine their probable methods of transmission and thus the kinds of material against which quarantine is needed.

Detection of potentially dangerous epidemics

An effective Nation-wide detection plan would provide for adequate technical leadership, utilizing information and advice of the technical bureaus of the Department of Agriculture and other agencies, and for full participation of public land-managing agencies, State agencies, and private landowners. It would draw on the facilities of each group mentioned and recognize their responsibilities and relation to the unified effort. It would include:

(1) An inspection unit of trained forest entomologists and forest pathologists in each forest region, to be responsible for obtaining and analyzing current information on insects and diseases within its region.

(2) Specially selected men in the administrative field personnel of public land-managing agencies, assigned to make regular, systematic

inspections at designated key points and report results to the detection unit. Similar arrangements would be developed with private owners.

(3) Close cooperation of all State agencies that obtain records of insect and disease pests. This is necessary for full efficiency and economy.

Control to suppress epidemics

As with forest fires, losses are minimized by control action that immediately follows detection of a pest outbreak. Generally, control operations aimed at pest outbreaks should be financed and conducted by the Federal Government on its own lands, cooperatively between the Federal and State Governments on State lands, and by the Federal and State Governments and private owners on private lands. The first objective of the Federal Government is to obtain effective application of control measures wherever needed.

In addition to the facilities now available, the opportunity for prompt and effective action to control epidemics would be improved by:

(1) Establishment of a Federal fund available to the Secretary of Agriculture for control operations whenever necessary. Such an arrangement should include authorization for the allocation of funds to other Federal land-managing agencies, and for cooperation with the States, and private owners.

(2) Establishment of similar funds by the States, to be available for independent action or for cooperation with the Federal Government and private owners. State authorizations should provide access by cooperating Federal and State agencies to private land for necessary control work.

Application of silvicultural and forest management practices

Forestry practices helpful in preventing or decreasing losses from forest insects and diseases have been discussed earlier in this report. As yet, their application is largely in the experimental stage, although some practices are of established value. On both public and private operations, and on special demonstration areas established for the purpose, there should be cooperative trials to determine their cost and workability in large-scale use, and what adaptations are needed to meet different sets of local conditions. Such trials would also be made to serve as demonstrations. They should be arranged through the leadership of the Federal agencies chiefly concerned--the Forest Service, the Bureau of Entomology and Plant Quarantine, and the Bureau of Plant Industry, Soils, and Agricultural Engineering--and would require the employment of specially trained entomologists and pathologists, in addition to those responsible for research.

There should be established a number of experimental and demonstration areas where practices designed to reduce the hazard of insect and disease epidemics can be thoroughly tested.

One of the greatest needs is for tests and demonstrations of silvicultural practices to prevent or reduce insect and disease losses in plantations. Throughout the country, many examples of severely damaged plantations give evidence that artificial reforestation is hazardous unless proper techniques are followed. Although present knowledge of how the activities of insects and diseases are influenced by such controllable factors as planting-site preparation, origin of planting stock, composition, and spacing is far from adequate, there are certain practices of proven value and others which give good promise of becoming so. With many millions of acres now in need of planting, the advice of forest entomologists and pathologists in plantation design is increasingly needed. Control measures applied after a plantation has been started cannot overcome the basic weakness of a poor design.

Information and demonstration

Bridging the gap between research and the application of its findings is an essential step in attaining satisfactory control of insect and disease pests. Private forest owners should be given information on preventive measures as well as on control measures to be taken after outbreaks have developed. The many inquiries received by research agencies about how to control forest insects and diseases are encouraging evidence of growing recognition of the need for proper technical guidance. Dissemination of results through ordinary publication and extension channels has proved insufficient to get them promptly into use. New methods of preventing or lessening losses, whether by direct action or by modification of ordinary silvicultural and utilization practices, should be demonstrated by competent specialists employed specifically for such work.

The general public also should be made aware of the danger to the forests from these destructive agents and, in general, of the kind of action that is necessary to control them. In other words, the public should have the same sense of awareness and responsibility toward destructive insects and diseases as toward forest fires.

APPENDIX

Table 4.---Examples of endemic losses caused by forest insects and diseases, by region

NEW ENGLAND AND MIDDLE ATLANTIC

Type or species of diseases and insects	Important timber species most affected	Kind of damage
White pine weevil	Eastern white pine, Norway spruce	Kills leaders, causing forked and crooked boles.
Root collar weevil	Scotch pine	Girdles young trees, sometimes causing death.
Pales weevil	Eastern white pine	Girdles and kills small seedlings for 2 or 3 years following logging of white pine.
Certain sawflies	All pines and spruces	Reduce growth as result of defoliation.
Forest tent caterpillar	Sugar maple, aspen, birch	Reduces growth as result of defoliation.
Spittle bug	Red pine, Scotch pine	Sucking insect; reduces growth.
Scales and aphids	All tree species	Sucking insects; reduce growth.
Cankers	Aspen, birches, basswood, oaks, walnut, yellow-poplar	Cause stem defects and cull; often weaken trees so that they break in windstorms; may kill young trees by girdling.
Leaf diseases	Sycamore	Growth reduced; occasional trees killed.
Heart rots	Balsam fir, aspens, oaks, white pine, beech, hemlock	Slow decay of heartwood.
Root fungi	White pine	Weaken or kill scattered trees in plantations.

Table 4.--Examples of endemic losses caused by forest insects and diseases, by region--continued

SOUTH ATLANTIC, SOUTHEAST, AND WEST GULF

Type or species of diseases and insects	Important timber species most affected	Kind of damage
Sawflies	All southern yellow pines	Reduce growth through defoliation.
Turpentine borer	Southern yellow pines	Bore holes lower wood quality and make trees subject to wind breakage; most common in turpentined stands.
Ambrosia beetles	Hardwoods and southern yellow pines	Bore holes lower wood quality.
Leaf-cutting ants	Southern yellow pines	Kill seedlings, particularly in plantations, causing understocking; most prevalent in Texas and Louisiana.
Cankers	Oaks, walnut	Lower wood quality and kill occasional trees.
Leaf diseases	Longleaf pine reproduction, sycamore, loblolly pine	Decrease rate of growth, especially in longleaf pine.
Heart rots	Oaks, yellow-poplar, beech, sweetgum	Slow decay of heartwood; often enter through fire scars.
Dry face of turpentined pines	Slash and longleaf pines	Causes partial or complete cessation of gum flow from chipped faces.
Stem rusts	Principally loblolly and slash pines	Causes death of seedlings and saplings, and degrade of stems of larger trees.

Table 4.---Examples of endemic losses caused by forest insects and diseases, by region--continued

LAKE STATES AND CENTRAL STATES

Type or species of diseases and insects	Important timber species most affected	Kind of damage
White grubs	Conifer plantations and nurseries	Destroy roots; reduce stocking.
Pine tortoise-scale	Jack pine	Sucking insect; reduces growth.
Sawflies	Jack pine and red pine	Reduce growth as result of defoliation.
White pine weevil	Eastern white and jack pine	Kills leaders, causing forked and crooked boles.
Locust borer	Black locust	Bore holes lower wood quality and make trees subject to wind breakage.
Nursery blight	Redcedar	Kills seedlings in nursery beds.
Cankers	Aspen, cottonwood, ash	Cause stem defects and cull; kill occasional trees.
Heart rots	Balsam fir, aspen, birches	Slow decay of heartwood; causes 16 percent cull in aspen in Minnesota.
Undetermined	Hemlock, birches	Mortality in older stands, especially in residual trees after partial cutting.

Table 4.--Examples of endemic losses caused by forest insects and diseases, by region--continued

NORTH ROCKY MOUNTAIN

Type or species of diseases and insects	Important timber species most affected	Kind of damage
Douglas-fir beetle	Douglas-fir	Kills scattered individuals in overmature stands
Larch sawfly	Western larch	Reduces growth as result of defoliation.
Lodgepole sawfly	Lodgepole pine	Reduces growth as result of defoliation.
Spruce budworm	Douglas-fir, true firs, lodgepole pine	Reduces growth as result of defoliation; increases susceptibility to attack by bark beetles.
Dwarf mistletoes	Larch, lodgepole pine	Parasitic plants; decrease growth rate of host trees.
Heart rots	Hemlock, white fir	Slow decay of heartwood; more prevalent in older stands.
Stem rusts	Lodgepole and ponderosa pines	Stunt, deform, and occasionally kill trees, especially seedlings and saplings.

Table 4.--Examples of endemic losses caused by forest insects and diseases, by region--continued

SOUTH ROCKY MOUNTAIN

Type or species of diseases and insects	Important timber species most affected	Kind of damage
Tip moths	Ponderosa pine	Kill buds, reduce growth.
Bark beetles	All conifers	Several species normally present that seldom cause extensive losses but kill a few trees in the stand each year.
Stem rusts	Ponderosa pine	Attack seedlings, saplings, and poles, reducing stocking or rate of growth.
Dwarf mistletoes	Ponderosa pine, Douglas-fir, lodgepole pine	Decrease rate of growth, predispose to beetle attack, or sometimes kill directly.
Cankers	Aspen	Cause stem defects and cull.
Heart rots	Aspen, ponderosa pine, Engelmann spruce, Douglas-fir, and white fir	Result in heavy cull in many areas.
Root rots	Ponderosa pine	Weaken trees, making them subject to beetle attack; in places, cause understocking in reproduction.

Table 4.--Examples of endemic losses caused by forest insects and diseases, by region--continued

PACIFIC NORTHWEST AND CALIFORNIA

Type or species of diseases and insects	Important timber species most affected	Kind of damage
Twig weevils	Douglas-fir and ponderosa pine	Kill twigs and reduce growth; localized mortality in young natural reproduction and plantations.
Red turpentine beetle	Ponderosa and Jeffrey pine	Bark killed in patches at base of mature trees, predisposing them to attack by the western pine beetle.
Matsucoccus scales	Ponderosa and sugar pine	Sucking insects; reduce growth by killing twigs.
Flatheaded borers	Ponderosa pine and Douglas-fir	Larvae attack tops of trees; cause reduced growth and sometimes death of the trees.
Dwarf mistletoes	Ponderosa pine	Grow on all sizes of trees, kill some, and decrease growth on others.
Root rot	Ponderosa pine, Jeffrey pine	Fungus kills roots; weakened trees subject to bark beetle attack.
Heart rots	Hemlock, white fir, Douglas-fir, incense cedar, redcedar, redwood	Prevalence varies in different areas; most serious in virgin stands.

Table 5.---Major epidemics of forest insects and diseases, by region

NEW ENGLAND AND MIDDLE ATLANTIC

Destructive agents	Host species	Outbreak periods	Estimate of--		Remarks
			Damage	Salvage	
Spruce budworm	Balsam fir and spruces	1805-15) 1870-80)	Heavy loss of fir and spruce	Probably negligible	Severe damage in eastern Canada as well as northern New England.
		1909-20	25 million cords	Negligible	Over 200 million cords of fir and spruce killed in Canada.
		1945-	None to date		Began in 1938 in Ontario; high mortality over 70,000 square miles in Ontario and Quebec.
Gypsy moth	Great variety of species		Extensive in New England	Considerable as fuel wood	Introduced in 1869; abundance varies greatly from year to year. Losses greatest in white pine and in oaks on poor sites.
Beech scale	Beech	1929-	Extensive killing in Maine and New Hampshire	Very little	First found in Maritime Provinces of Canada; nectria disease follows insect infestation.
European spruce sawfly	Spruces	1933-40	Growth reduction and limited killing in northern New England		10 million cords killed on Gaspé Peninsula; outbreak checked in 1940 by a disease of the insects.
Undetermined	Yellow and paper birch	1943-	Half of mature birch killed over extensive areas in eastern Maine	Partial	Heavy losses in eastern Canada, Maine, Massachusetts, New Hampshire, and New York, at intervals in past years.

Table 5.--Major epidemics of forest insects and diseases, by region--continued

NEW ENGLAND AND MIDDLE ATLANTIC

Destructive agents	Host species	Outbreak periods	Estimate of--		Remarks
			Damage	Salvage	
White pine blister rust	Eastern white pine	1906-	Severe localized loss of seedlings and saplings, and considerable damage in some merchantable stands prior to control work	Partial salvage in merchantable stands; scattered infected trees usually a total loss	Effective control being obtained within areas selected for protection; in unprotected areas where ribes are abundant, damage is severe.
Chestnut blight	Chestnut	1904-	Complete destruction of commercial timber	Most of merchantable material, though considerable deterioration	Brought from Asia. Over large parts of area, forest productivity definitely decreased, since the replacing species are less desirable. No known control.
Dutch elm disease	All U.S. elms	1931-	Large number of trees killed in New Jersey, New York, and Connecticut	Negligible, mostly for fuel wood	Brought from Europe. Spread delayed by early control program. Economic loss mostly in shade trees. Recent outbreak in Ontario, Canada.

Table 5.--Major epidemics of forest insects and diseases, by region--continued

SOUTH ATLANTIC, SOUTHEAST, AND WEST GULF

Destructive agents	Host species	Outbreak periods	Estimate of—		Remarks
			Damage	Salvage	
Southern pine beetle	All southern pines	1890-92	Heavy killing over 75,000 square miles	Generally very little; rapid degrade caused by blue stain	Outbreaks generally associated with drought periods; often localized.
		1908-11	$2 million loss		
		1925-27) 1931-32) 1937-38) 1945-46)	Localized outbreaks; damage unknown		
Ips beetles	All southern pines	1924	100 million board feet	Partial	Outbreak caused by severe drought in 1923-24.
Little leaf; cause undetermined	Shortleaf pine	1932-	In South Carolina, Georgia, and Alabama, ¼ of pine area affected; on this, 25% of the trees killed over a 10-year period.	Perhaps one-fourth	Forces cutting of living trees too early for profit or for good saw-timber production.
Wilt	Persimmon	1932-	Most of larger trees destroyed in Tennessee Basin and at points in Southeast Region	Unknown	Commercial stands in lower Mississippi Valley not yet invaded.
Phytophthora root disease	Chestnut and Ozark chinquapin	1800-	Chestnut largely disappeared from Coastal Plain	Unknown	Range of chestnut said to be narrowed by 75 miles prior to advent of chestnut blight.
Chestnut blight	Chestnut	1925-	Complete destruction of commercial stand	Most of merchantable material, though considerable deterioration	Tannin extract wood can be used many years after death of trees.

Table 5.--Major epidemics of forest insects and diseases, by region--continued

CENTRAL AND LAKE STATES

Destructive agents	Host species	Outbreak periods	Estimate of--		Remarks
			Damage	Salvage	
Larch sawfly	Tamarack (eastern larch)	1910-20	One billion board feet	Considerable, because wood deteriorates slowly	Killed practically all mature stands in Lake States.
Spruce budworm	Balsam fir, spruces	1913-26	20 million cords	Very little	Over 75 percent of mature fir killed; some loss of white spruce but very little of black spruce.
Phloem necrosis (virus, origin unknown)	American elm	1900? 1918-	40-80 percent killed in some areas	Negligible, mostly for fuel wood	Scattered and intermittent outbreaks; main damage in street trees thus far; a threat to all American elms.
Dutch elm disease	All U.S. elm species	1943-	Little damage to date	Negligible, mostly for fuel wood	Now spreading so rapidly that heavy damage is expected.
Wilt	Black oak species	1910-	Many thousands of trees killed	Considerable	Reduced proportion of black oaks, especially in Wisconsin, northern Illinois, and Iowa.
White pine blister rust	Eastern white pine	1916-	Severe localized loss of young growth and considerable loss in some merchantable stands prior to control work	Partial salvage in merchantable stands	Effective control being obtained within areas selected for protection; in unprotected areas where ribes are abundant, damage is severe.

Table 5.--Major epidemics of forest insects and diseases, by region--continued

NORTH AND SOUTH ROCKY MOUNTAIN

Destructive agents	Host species	Outbreak periods	Estimate of--		Remarks
			Damage	Salvage	
Black Hills beetle	Ponderosa pine	1895-1908	Nearly 2 billion board feet of pine killed		Outbreak in Black Hills region of South Dakota.
		1917-25	Over 300 million board feet		Outbreak on Kaibab National Forest, Ariz.
		1923-30	100,000 trees killed	Very little	On Roosevelt National Forest in Colorado.
		1935-44	No estimate of losses		Over $1 million spent on control work, largely by the CCC.
		1946-	Over 50,000 trees already killed		Threatening to become major outbreak on Roosevelt and Black Hills National Forests.
Engelmann spruce beetle	Engelmann spruce	1940-	4 billion board feet	Very little	95 percent of merchantable trees killed on White River Plateau in Colorado; about 20 percent of the spruce in the State has been killed.
Mountain pine beetle	Western white pine	Several outbreaks since 1910	3½ billion board feet		Complicated in some areas by a predisposing agent of uncertain character.
	Ponderosa pine		5½ billion board feet	Very little	Most severe losses in 1931-32.
	Lodgepole pine		6 billion board feet		A severe outbreak began in 1943 on Caribou, Targhee and Teton National Forests.

Table 5.--Major epidemics of forest insects and diseases, by region--continued

NORTH AND SOUTH ROCKY MOUNTAIN

Destructive agents	Host species	Outbreak periods	Estimate of--		Remarks
			Damage	Salvage	
Pine butterfly	Ponderosa pine	1922-23	25 percent of stand killed over large area in Idaho	Very little	Western white pine also attacked.
Fir tussock moth	Douglas-fir, true firs	1945-	Severe defoliation on about 350,000 acres		Outbreak is located east of Moscow, Idaho; about two-thirds of area is privately owned.
White pine blister rust	Western white pine	1927-	Loss of younger growth ranges up to 100 percent on certain areas, with some infection in pole stands; large areas of young growth in some drainages are a total loss	Existing mature timber can probably be harvested without appreciable loss	Effective control being obtained by ribes eradication and silvicultural practice.

Table 5.--Major epidemics of forest insects and diseases, by region--continued

PACIFIC NORTHWEST AND CALIFORNIA

Destructive agents	Host species	Outbreak periods	Estimate of—		Remarks
			Damage	Salvage	
Western pine beetle	Ponderosa pine	1917-43	Over 25 billion board feet	Very little	Losses nearly equal to cut of pine lumber; epidemics apparently cyclic in character.
Pine butterfly	Ponderosa pine	1893-95	1 billion board feet killed on 140,000 acres	None	Mature stands in six townships practically wiped out on Yakima Indian Reservation, Wash.
Pandora moth	Ponderosa pine	1918-25	Several million board feet on 20,000 acres	Partial	Outbreak occurred on Klamath Indian Reservation, Oreg.; losses increased by subsequent bark beetle attack.
Pine engraver beetles	Ponderosa and sugar pines	1914-15) 1930-31) 1943-45)	Heavy localized losses in second-growth stands and tops of mature trees	Very little	Outbreaks frequently followed by increased activity of other bark beetles.
Mountain pine beetles	Lodgepole and western white pine	1919-32	40,000 acres of pine decimated	None	Outbreak occurred in Crater Lake National Park, Oreg., and adjacent national forest lands.
Lodgepole needle miner and mountain pine beetle	Lodgepole pine	1910-20	90 percent of lodgepole pine killed over 30,000 acres	None	"Ghost forests" of Yosemite National Park, Calif.
Mountain pine beetle	Western white pine	1925-35	3,000 acres of susceptible pine stand largely killed	None	Outbreak centered in Mount Rainier National Park, Wash.

Table 5.--Major epidemics of forest insects and diseases, by region--continued

PACIFIC NORTHWEST AND CALIFORNIA

Destructive agents	Host species	Outbreak periods	Estimate of--		Remarks
			Damage	Salvage	
Douglas-fir beetle	Douglas-fir	1935	200 million board feet	Partial	Outbreak followed large Tillamook Burn of 1933, Oregon.
		1938	100 million board feet	Partial	Outbreak followed extensive fires in Oregon, 1936.
Fir tussock moth	Douglas-fir and white fir	1928-30	300 million board feet	Very little	Outbreak centered in northeastern Washington.
Fir tussock moth	White fir	1933-39	158,000 trees killed on 15,000 acres	None	Losses mainly on Inyo National Forest, Calif.
Fir engraver beetle	White fir	1924-32	15 percent of stand killed and 25 percent damaged	None	Extensive damage over wide area in the central Sierra Nevada Mountains of California.
Hemlock looper	Western hemlock	1889-91	Extensive loss	None	Tillamook and Clatsop Counties, Oreg., and Gray's Harbor County, Wash.
		1918-21	500 million board feet	Very little	Tillamook and Clatsop Counties, Oreg.
		1929-32	200 million board feet	Very little	Pacific County, Wash.
		1944-46	40 million board feet	Considerable	Clatsop County, Oreg.
White pine blister rust	Western white pine and sugar pine	1925-Oregon 1936-Calif.	In Oregon and northern California severe damage in young pines outside protected areas.	Existing mature timber can probably be harvested without appreciable loss	Effective control being obtained within protected areas; in northern California elimination of known infection centers is delaying the development of the disease.

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